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# CERTIFICATE

This certificate is issued in support of an application for Patent registration in a country outside New Zealand pursuant to the Patents Act 1953 and the Regulations thereunder.

I hereby certify that annexed is a true copy of the Provisional Specification as filed on 18 March 2004 with an application for Letters Patent number 531822 made by PRECISION DISPENSING SYSTEMS LIMITED.

Dated 11 April 2005.

Neville Harris

Neville Harris
Commissioner of Patents, Trade Marks and Designs

COMMISSIONER OF PATENTS, TRADEMARKS & DESIGNS
NEW ZEALAND

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**PROVISIONAL SPECIFICATION**

# A PUMP

WE, PRECISION DISPENSING SYSTEMS LIMITED a New Zealand company of 25 Matipo Street, Palmerston North 5301, New Zealand do hereby declare this invention to be described in the following statement:-

This invention relates to a pump. More particularly the present invention relates to a membrane pump.

Pumps, which incorporate a flexible element to achieve the pumping action, are known. For example, the flexible element can be in the form of a deformable tube and a pump of this type is described in our international patent specifications WO 99/01687 and WO 02/18790.

In WO 02/18790 there is described a pneumatic pinch mechanism for a deformable tube and, in particular, the mechanism when applied to the pump. The mechanism includes a piston movably located within the chamber with vent means so that at some point during the movement of the piston between the first and second positions, a pressure equalisation occurs within the second chamber. Consequently, as the piston moves toward a first position a pressure increasing occurs which can be used to deform the deformable tube. When the piston moves toward a second position, a negative pressure is created which can be used to return the deformable tube from its deformed configuration.

The pump has proved successful, but as with deformable tube pumps, the deformable tube can require regular

replacement. This is generally due to the repeated closing and release of the tube leading to localised wear or fatigue in the tube, which can ultimately lead to the tube rupturing.

A further disadvantage with such pumps is that it is often difficult or not possible to produce a deformable tube (having the necessary characteristics of being able to deform and rebound or be returned to its non-deformed state) from a material, which is particularly suited for handling the materials intended to flow through the pump.

A membrane pump therefore provides an advantage that the membrane can be formed from a material, which has a wide range of applications, and indeed materials which are required in some applications, but which cannot be formed or economically formed into replaceable deformable tubes for use in pumps having cyclic deforming of the tube. However, membrane pumps to date are of constructions, which still give rise to mechanical stress in the diaphragm, thereby requiring regular replacement of the diaphragm. Also, many known diaphragm pumps fall short in performance, especially in achievement of full removal of fluid from the pump chamber on the exhaust stroke and full uptake on the inlet stroke.

It is therefore an object of the present invention to provide a membrane pump, which is of a construction resulting in reduction in mechanical stress in the membrane, thereby leading to longer membrane life.

It is a further object of the present invention to provide a membrane pump of a construction, which enables full removal of fluid on the exhaust stroke and fuller uptake on the inlet stroke during operation of the pump.

Broadly according to one aspect of the invention there is provided a pump including a cavity with an inlet port and an outlet port opening into and from the cavity, a flexible membrane located within the chamber and arranged to be bi-stable in two states corresponding to completion of inlet and exhaust of a pumping cycle.

In the following more detailed description of the invention according to one preferred embodiment, reference will be made to the accompanying drawings in which:-

Figure 1 is a longitudinal cross-section through the pump,

Figure 2 is an exploded view in cross-section of the pump as shown in Figure 1,

Figure 3 is a transverse cross-sectional view taken between the inlet and outlet ports and showing the two sections of the pump body,

Figure 4 is a perspective view of one housing section of the pump,

Figure 5 is a further cross-sectional view of the pump as shown in Figure 1 in conjunction with a control mechanism,

Figure 6 is a schematic view of the pump on an exhaust cycle, and

Figure 7 is a view similar to Figure 6 but of the inlet cycle.

Referring firstly to Figures 1-3, the pump 10 is, according to a preferred embodiment, formed of two housing sections 11 and 12, which when assembled together define an internal pump cavity 13. Clamped between the

housing sections 11 and 12 as will hereinafter be described, is a membrane 14 which is made from a suitable flexible material.

In the preferred form of the invention, the cavity 13 is elongate and as shown in Figure 4, each end 15 is curved. In cross-section as shown in Figure 1, each end is also curved as indicated at 15. Furthermore, in transverse cross-section as shown in Figure 3, the cavity is also of curved cross-section.

Housing section 11 incorporates a rebate 16, which effectively results in an upstand or projecting portion 17. Thus, the cavity 13a is effectively located at least in part in the resultant upstanding portion 17.

The other housing section 12 has a recessed portion 18 with cavity section 13b extending down from the floor of the recess 18. Thus, when the two housing sections 11 and 12 are brought together the projecting portion 17 engages snugly within recess 1. However, the arrangement is such that surface 20 of projecting portion 17, terminates a distance from the floor 19 of recess 18. In the preferred form of the invention, this distance D (see Figure 1) is less than the thickness of the membrane 14.

The reason for this gap D will hereinafter become apparent.

The membrane 14 is in the preferred form of the invention, cut from sheet material, this material being elastomeric and of a type which is compatible with the material, which is intended to be pumped through the pump 10. For example, if the material to be pumped through the pump is corrosive, then the membrane material is selected such as to be able to withstand the corrosive nature of the fluid. By way of further example, the membrane is selected from a food grade material in the event that the pump is to handle a liquid foodstuff.

The various types of materials and applications to which a pump of this type can be put are well known to those skilled in the art and therefore further description herein is not necessary for the purposes of describing the construction and operation of the pump according to the invention.

According to the invention, the membrane 14 is cut in a shape and to a size, which enables it to be snugly fitted into the recess 18. However, the overall peripheral dimensions of the membrane 14 are greater than the

peripheral dimensions of the sidewall 21 of the recess 18. As a result, when the membrane 14 is placed into the recess 18 compressive forces are set up in the membrane due to the interference fit of the membrane 14 into the recess 18. This therefore causes the membrane to deform from its flat state into a state, which essentially conforms with the complex curved shape of the cavity section 13b.

However, when the housing section 11 is combined with housing section 12 (the membrane 14 being in place in recess 18) the fact that space D is less than the thickness of the membrane causes the peripheral edge portion of the membrane 14 to be sandwiched and clamped between opposing surfaces 19 and 20. This clamping force provides yet further compressive forces in the membrane, which causes it to even more closely adapt into the shape of the cavity section 13b. Thus, in effect the membrane 14 is in contact with, or located closely adjacent to the overall surface of the cavity section 13b.

A port 22 is formed in the housing section 12 and opens into the cavity section 13b. This port 22 can be offset as shown in the drawings or else it can be located midway in the length of the cavity 13.

In one form of the invention, a narrow groove can be formed in the wall of the cavity section 13b and extend along the length of the cavity 13 either side of from the port 22. Also a similar narrow groove can be formed in cavity 13b. The effect of the narrow groove is to prevent the pump from "choking" when the membrane approaches contact with the surface of the cavity. Such contact could prevent fluid flow from occurring and thereby result in the cavity not fully filling or exhausting. The narrow groove ensures that flow occurs right down to when the membrane comes into full overall contact with the cavity surface.

As each end of the cavity section 13a is a port, which opens from the cavity 13 to the outer surface 23 of housing section 11. Port 24 operates as an inlet port while port 25 operates as an outlet or exhaust port. Each of ports 24 and 25 can, as shown, be made up by a plurality of separate passages 24a and 25a respectively. A recess 26 is formed in the surface 23 of housing section 11 and into this is engaged a disk of flexible material which forms valve element 27. Likewise, a valve element 28 is provided in the exhaust valve 25 but it locates in a recess 29 in cover 30.

Cover 30 has connecting pieces 31 and 32 respectively which provide connections for an inlet line (not shown) to inlet valve 24 and an outlet or exhaust line (also not shown) from exhaust valve 25.

The arrangement of the membrane 14 in the cavity 13 as described above, results in the membrane 14 being bi-stable. In one stable position, the membrane is shown in the drawings whereas in the other stable position (shown in dotted detail) the membrane 14 is of the same configuration but located within the cavity section 13b. In effect therefore, the membrane 14 adopts a stable position in either a position which conforms with completion of intake of fluid through inlet valve 24 (i.e. the position shown in the drawings) and a full or completed exhaust position.

The membrane 14 is moved between its two stable positions by application negative P1 and positive P2 pressures applied to cavity 13b through port 22. Consequently with the pump in the configuration shown in Figure 1 and inlet and outlet conduits or lines attached to connectors 31 and 32 a positive pressure P2 (see Figure 6) applied through port 22 will force the membrane 14 into its

opposite stable position. In this "stroke" of the membrane 14, the inlet valve 24 is forced closed while the outlet valve 25 is forced open and any fluid within the cavity 13 is exhausted through the outlet valve 25.

Upon this "stroke" having been completed a negative pressure P1 applied via port 22 (see Figure 7) causes the membrane 14 to return to the position shown in Figure 1 which also causes the exhaust valve 25 to close but the inlet valve 24 to open and enable fluid in the inlet line to be drawn into cavity 13. The cavity thus fills with the fluid ready to be exhausted through the outlet valve 25 upon the next cycle occurring when membrane 14 moves back into cavity section 13a.

The means for applying negative and positive pressures can take on many forms as will be apparent to the person skilled in the art. The means could comprise, for example, sources of positive and negative pressure, which via suitable valves can be coupled to the port 22.

An example of a mechanism we have described for applying the positive and negative pressures via port 22 is shown in Figure 5.

As shown the pneumatic operator 33 has a body 34 which defines a chamber 35 in which a piston 36 is reciprocally mounted. A piston rod 37 is pivotally connected via pivot 38 to the piston 36. This piston rod 37 is pivotally connected by pivot 39 at its other end to a rotating drive member 40. The drive member 40 is connected to a drive means (not shown) which can be in the form of an electric motor or some other form of motive power.

A port 41 in the end wall 42 of the body 34 is in communication with port 22. As shown in Figure 4 the body 34 is in close proximity to the pump 10 but it will be appreciated by those skilled in the art that the pneumatic operator 33 could be located quite some distance away from the pump 10 and connected by a conduit extending between ports 22 and 41.

A port 43 in the wall of body 34 is connected to a conduit 44 which is connected to a conduit 44 which is in turn connected to a vent housing 45. One wall of the vent housing 45 has a vent opening 49 which opens into a chamber 50 in which a pin 51 is moveably located. The pin 51 is therefore moveable between the position where

conduit 44 is isolated from vent 49 to a position where the vent 49 is connected to conduit 44.

Mounted with a periphery of the driving member 40 and projecting therefrom is a pair of curved or shaped (e.g. ramped) projections 52 and 53. Consequently, as the rotating member 40 rotates, a projection 52 or 53 comes into contact pin 51 which forces the pin 51 inwardly (relative to the housing) thereby connecting or disconnecting the vent 49 from the conduit 44.

This action causes the chamber 35 to vent to atmosphere (via vent 49) for the period of time that the pin 51 fails to seal closed the conduit 44. In the preferred form of the invention the pin 51 is biased by suitable biasing means (not shown) such as a spring or the like into a position where the vent 49 is closed i.e. isolated from conduit 44.

As a consequence, continued movement of the piston 36 creates a positive pressure build up which via port 22 forces the membrane 14 from the position shown in Figure 4 to its other stable position in cavity section 13b. Material within the cavity 13 is thus forced out through the exhaust port 25.

As the piston 36 moves back along the chamber 35 from the second position the vent port 49 will still be closed. This will continue to be the situation until the engagement projection 52 comes into contact with pin 51 to effectively open the vent port 49. As a result, the vent port 49 once again vents the chamber 35 to atmosphere. After the vent 49 is closed from conduit 44 by movement of the pin 51 and as a result of the pin clearing the projection 52, the continued movement of the piston 36 back to its first position will create a negative pressure.

This negative pressure build up will cause the membrane 14 to move back to the position shown in Figure 4 thereby creating a negative pressure within the chamber 13 which draws pumpable medium on the inlet 24 to be drawn through the inlet valve 24 and into the cavity 13. This inflow will continue until the membrane 14 is fully back into its position shown in Figure 4.

Preferably the point and the movement of the piston 36 where contact between the pin 51 and projections 53 respectively occurs is adjustable. According to the preferred form of the invention, projections 52 and 53

can be adjustable in position on the periphery of the driving member or rotor 40 so that, for example, the period during which the piston creates a positive pressure could be less. This would result in the time that the membrane is under negative pressure to be greater than the period that it is under positive pressure.

The bi-stable flexible membrane 14 effectively has a small amount of travel between its two states. It is not mechanically connected to any drive thereby giving the membrane free movement in the cavity 13. The cavity shape is round rectangular and its contoured to fit the bi-stable shape of the membrane. Consequently, the cavity supports the diaphragm over its full surface when the diaphragm is in a so-called stable state. The membrane is therefore subject to uniform pressure not only when in the stable states but during the transition between the states as it is supported on both surfaces by the incoming or outgoing pumpable medium and the positive or negative pressure applied across the whole membrane surface via port 22.

It is believed that the bi-stable nature of the membrane, the cavity shape and contour, as well as the uniform

pressure to which the membrane is subjected will lead to a significant reduction in mechanical stress on the membrane. This will therefore equate to longer membrane life. Furthermore, during operation of the pump there will be full removal of fluid on the exhaust stroke and full uptake on the inlet stroke as the membrane 14 moves fully from contact and support within the two sections of the chamber.

The pump therefore provides maximum efficiency and good linear flow characteristics, the latter being more critical as viscosity of the pumpable medium increases. The outlet pressure will be governed by the drive pressure therefore no need for pressure limiting. Suction (lift) is governed by the negative pressure. There is thus consistent through put over a wide range of drive pressures.

The valve 24 and 25 are located at the half round extremities of the cavity and in close proximity to the cavity. This proximity of the valves to the cavity thus minimises voids thereby giving optimum dry prime and compression ratio.

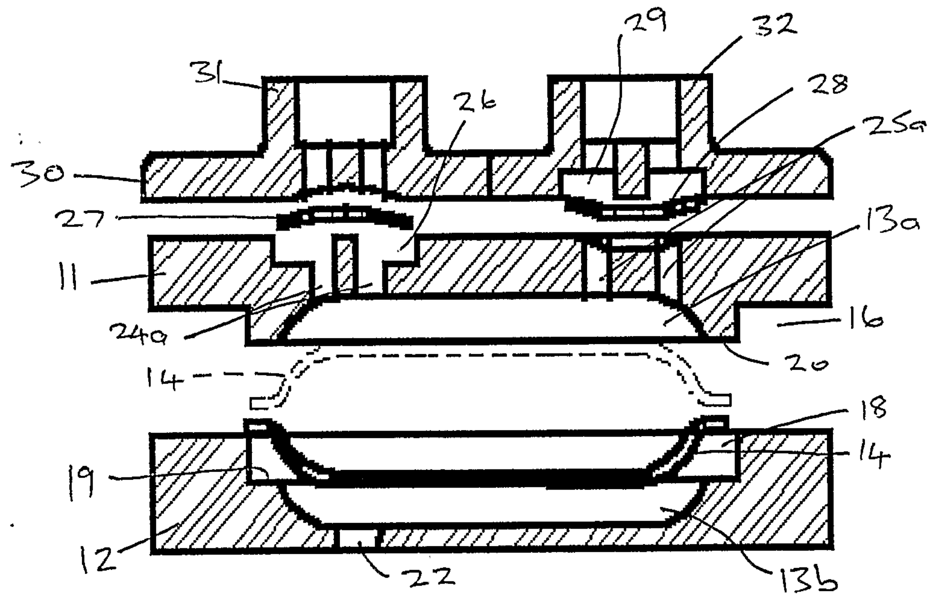
The pump arrangement is such that only low inertia needs to be overcome in order to drive the membrane. The valves are progressively closed and finally close before full exhaust or intake. This means that the last thing to occur as the membrane 14 reaches its stable position is movement of the valves into a closed position or opening is the first thing to occur upon the membrane 14 moving from a stable position.

The invention as described herein is by way of example only and it will be appreciated by those skilled in the art that other embodiments incorporating the invention are possible.

PRECISION DISPENSING SYSTEMS LIMITED
By its Attorney
DON HOPKINS & ASSOCIATES

Per:

FIG. 2.



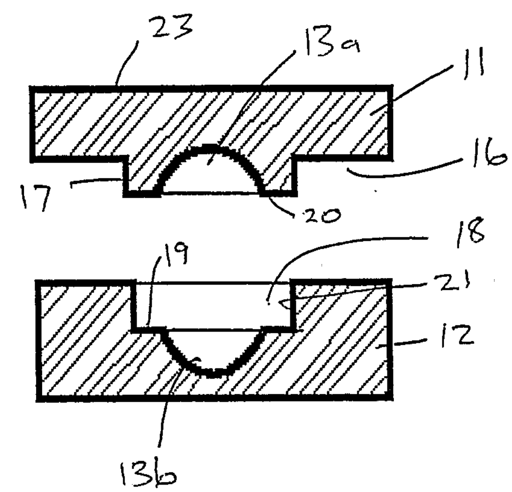




FIG. 3.

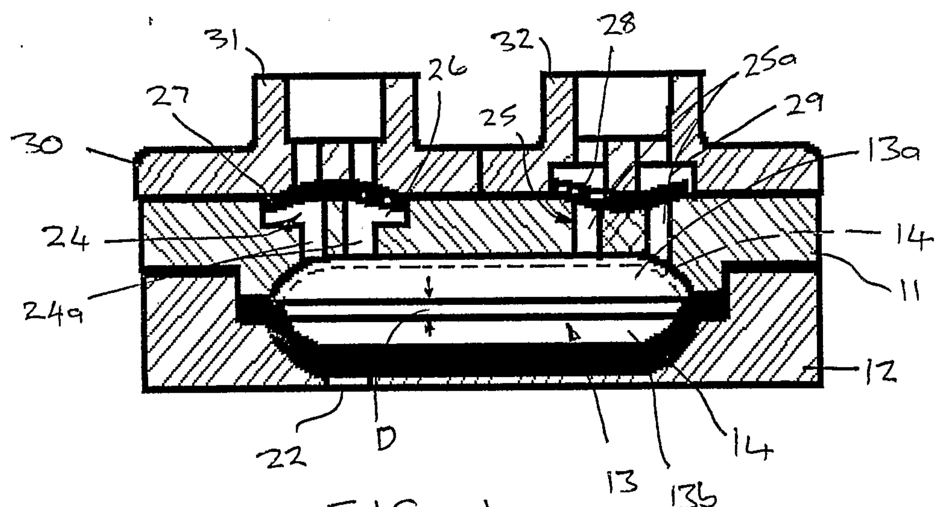
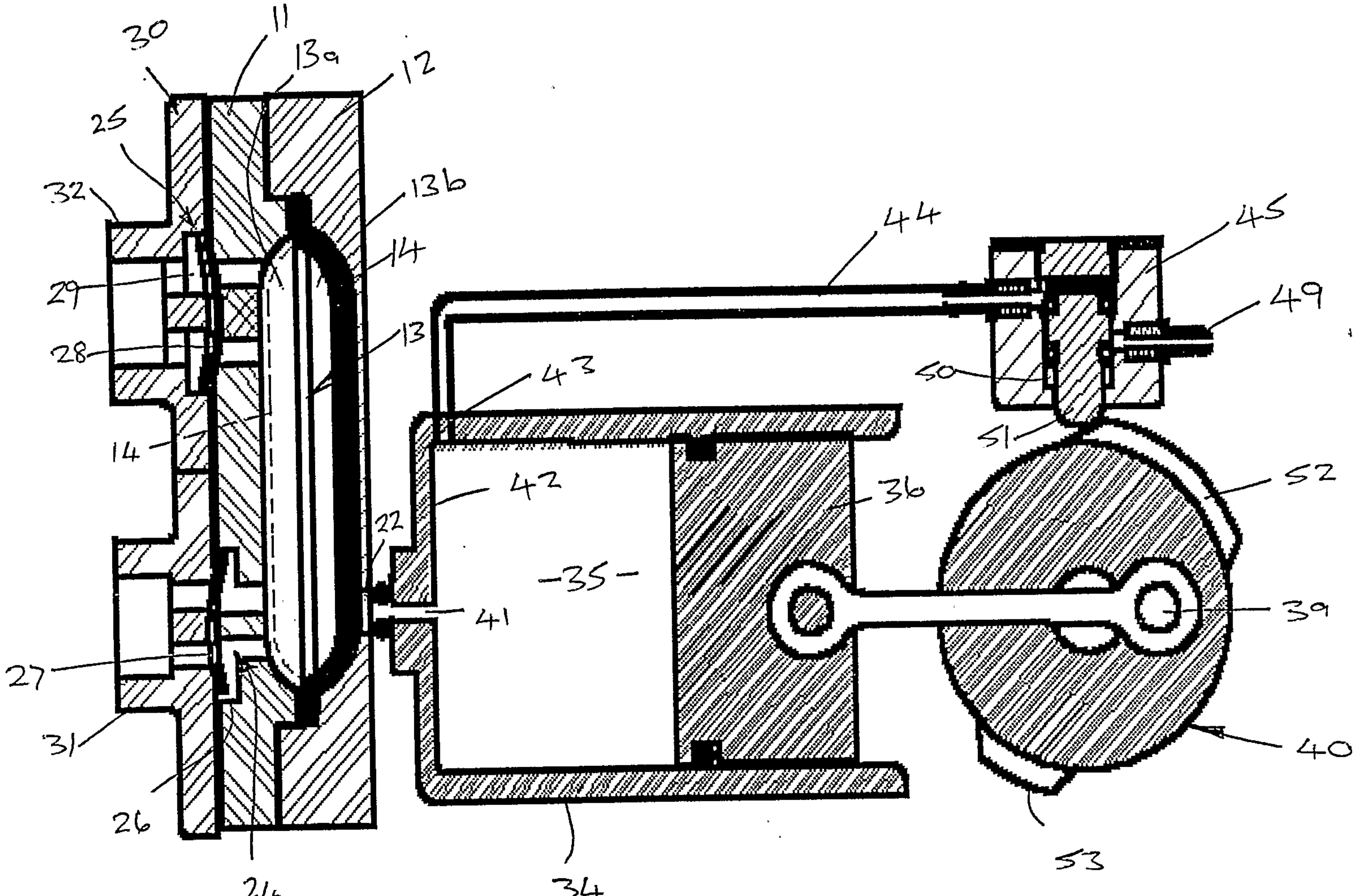



FIG. 1.



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13a
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13b
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FIG. 5.

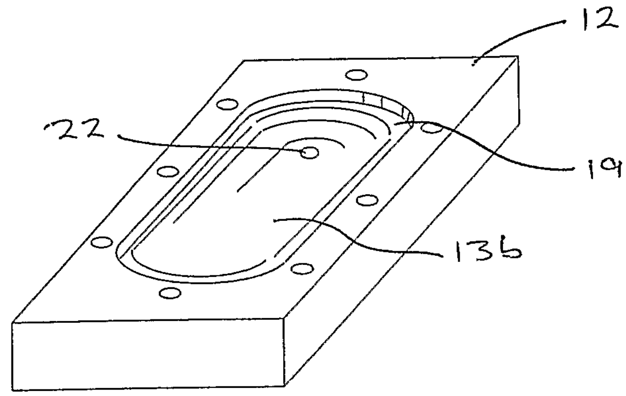


FIG. 4.

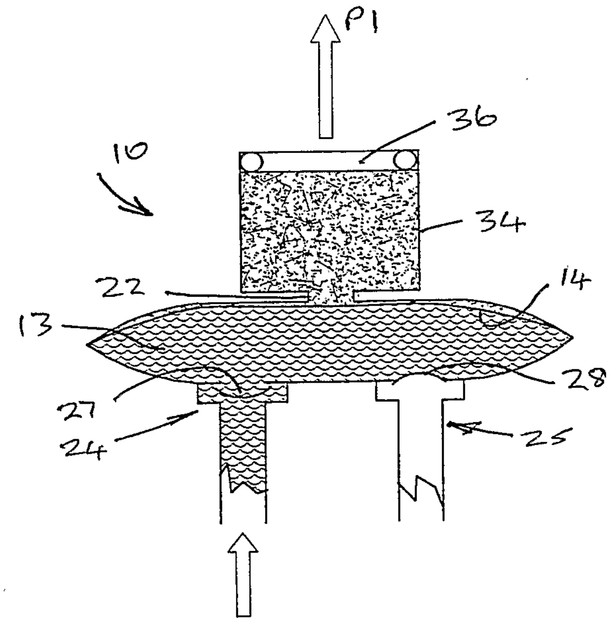


FIG. 7.

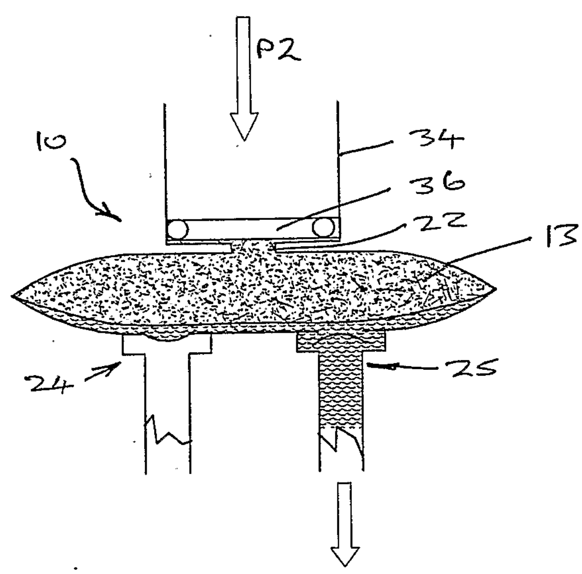


FIG. 6.